Useful formulae: [Note that you may not need all of these formulae. Use as needed]

Utilization:

- $a = \dfrac{Tprop}{Trans} = \dfrac{propagationDelay}{transmissionDelay}$

- $propagationDelay = \dfrac{Dis\,\tan ce}{S}$, S=2x10^{8}m/s

- For stop-and-wait: $u = \dfrac{1-p}{(1+2a)}$, where p is the probability that a frame is in error.

Utilization for sliding-window mechanisms with window of w:

- Go back N: $u = \dfrac{1-p}{1+2ap}$, if w fills the pipe, or $u = \dfrac{w(1-p)}{(1+2a)(1-p+wp)}$ otherwise

- Selective repeat: $u = (1-p)$, if w fills the pipe, or $u = \dfrac{w(1-p)}{(1+2a)}$ otherwise

- TCP:
  - slow start CongWin+=1 per ACK,
  - congestion avoidance CongWin+=1 per RTT,
  - EstimatedRTT(k)= (1-α)*EstimatedRTT(k-1) + α*SampleRTT(k), 0<α<1
  - DevRTT= (1-β)*DevRTT+ β*|SampleRTT – EstimatedRTT|, 0< β <1
  - TimeoutInterval = EstimatedRTT + 4*DevRTT

ATM ABR rate-based congestion control:

- Increase: Rate = min(PCR, Rate + PCR x RIF)

- Decrease: Rate = max(MCR, min[ER, Rate – Rate x RDF])

Probability distributions and stochastic processes:

- Geometric distribution: *x* is the number of Bernoulli experiments until success, Pr[X=k]=q^{k-1}p, E(X)=1/p

- Binomial distribution: *x* is the number of successes in *n* Bernoulli experiments/trials
  $P(X=k) = \binom{n}{k} q^{n-k} p^{k}, \binom{n}{k} = \dfrac{n!}{(n-k)!k!}$, E[X]=np